

Announcements

- ▣ Homework for tomorrow...
Ch. 22, CQ 3, Probs. 2, 4, & 8

- ▣ Office hours...
MW 10-11 am
TR 9-10 am
F 12-1 pm

- ▣ Tutorial Learning Center (TLC) hours:
MTWR 8-6 pm
F 8-11 am, 2-5 pm
Su 1-5 pm

Chapter 22

Wave Optics

*(Light and Optics &
The Interference of Light)*

Last time...

- *Frequency, f , and period, T ...*

$$f = \frac{1}{T}$$

- *The wave speed is...*

$$v = \lambda f$$

- *The index of refraction is...*

$$n \equiv \frac{c}{v}$$

- *The wavelength in a material is...*

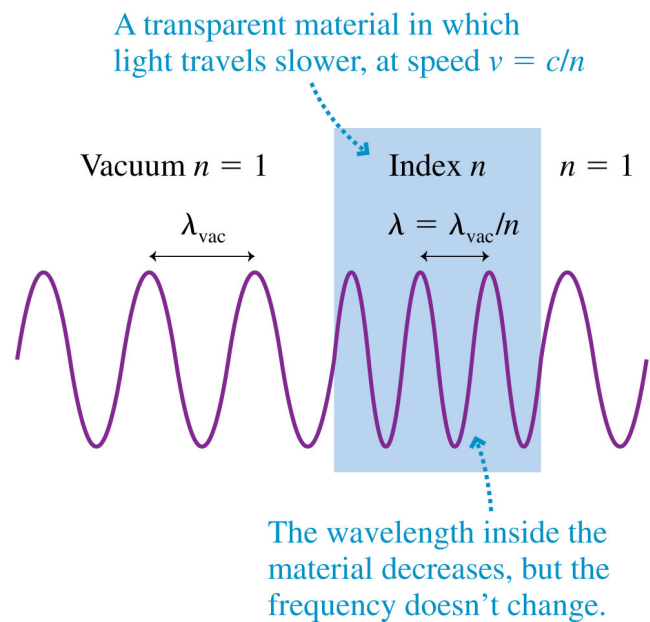
$$\lambda_{mat} = \frac{\lambda_{vac}}{n}$$

i.e. 20.8

Light traveling through glass

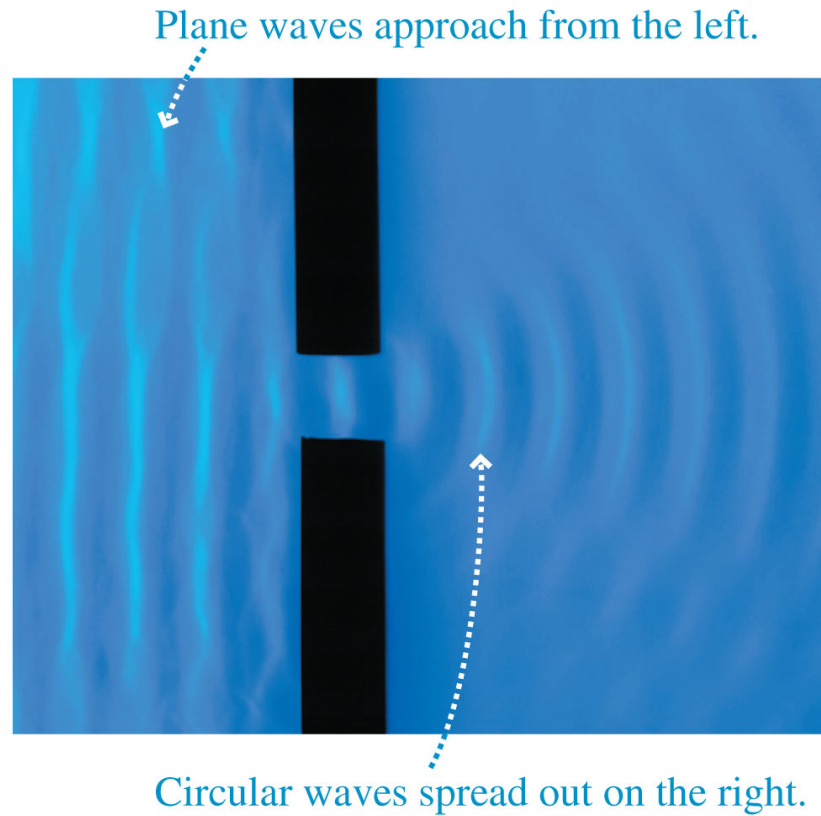
Orange light with a wavelength of 600 nm is incident upon a 1.00 mm thick glass microscope slide.

- What is the light speed in the glass?
- How many wavelengths of the light are inside the slide?

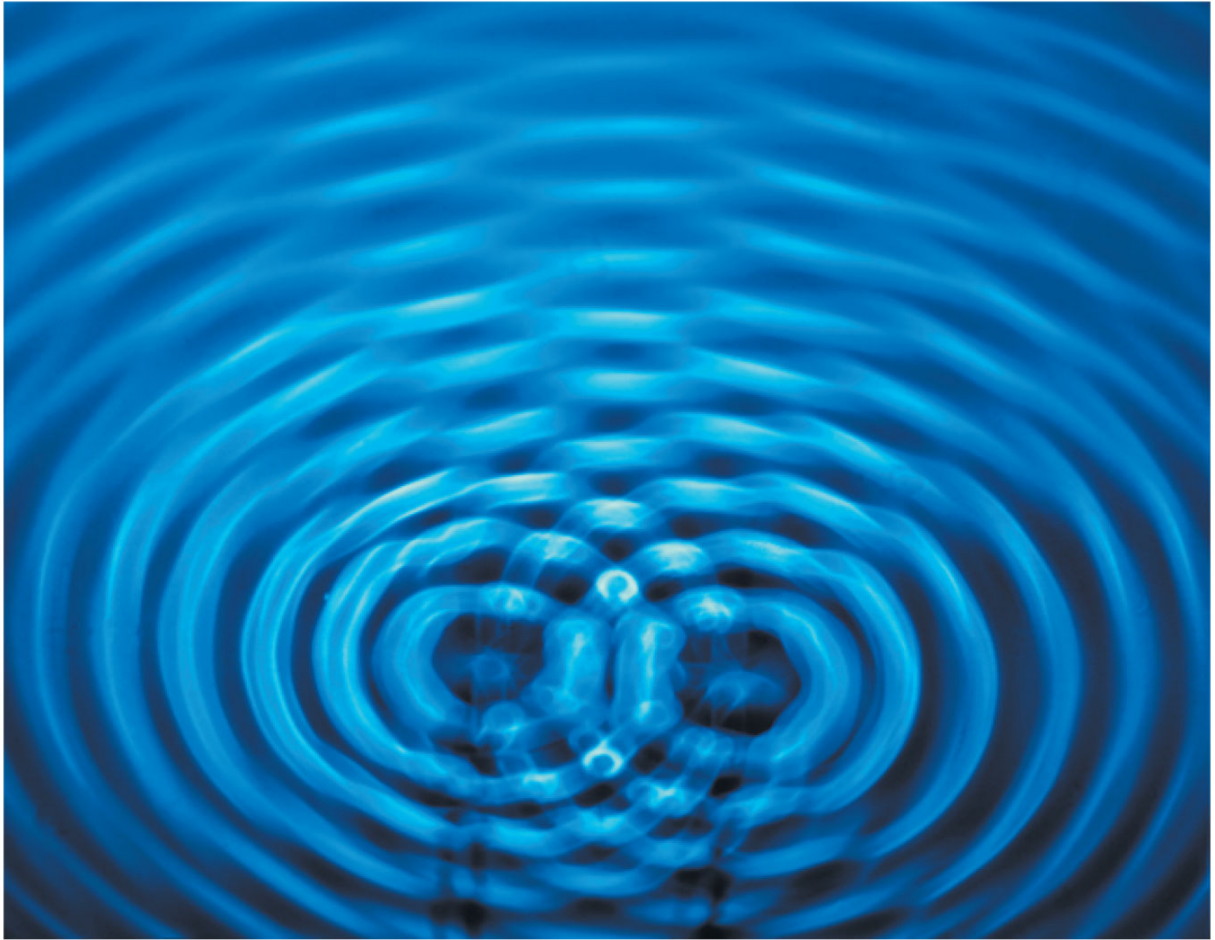


Diffraction of H₂O Waves...

- A H₂O wave, after passing through an opening, *spreads out* to fill the space behind the opening.
- *Diffraction* = spreading out of waves.
- All waves experience *diffraction*.



Interference...



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Diffraction of Sunlight?

- ❑ Unlike a H_2O wave, when light passes through a large opening, it makes a *sharp-edged* shadow.
- ❑ This lack of noticeable diffraction means that *if* light is a wave, the wavelength must be *very small*.
- ❑ So, is light a wave or a particle?



22.1: Light and Optics

Does light consist *of waves* or *of particles*?

Isaac Newton (1660)

- does not witness *diffraction* of sunlight.
- concludes that light must consist of *very small, light, fast particles* that he calls *corpuscles*.

Thomas Young (1801)

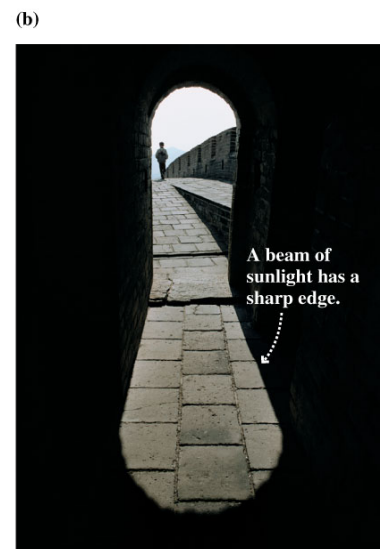
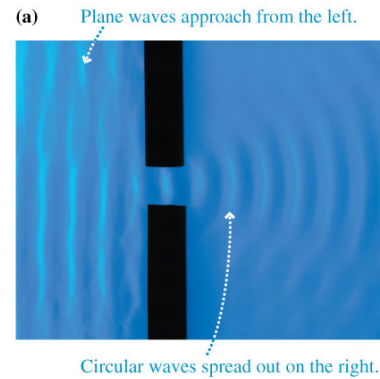
- produces *interference* between two waves of light.
- concludes that light consists of *waves* (but *WHAT* is waving?).

James Maxwell (1860)

- Maxwell equations predict EM *waves* that travel at a speed c !

Albert Einstein (1905)

- Photoelectric effect
- Light consists of *photons* w/ BOTH wave-like & particle-like properties!



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Models of Light...

Wave Model:

- ❑ Under many circumstances, light exhibits the same behavior as sound or water waves.
- ❑ The study of light as a wave is called *wave optics*.

Ray Model:

- ❑ The properties of prisms, mirrors, and lenses are best understood in terms of *light rays*.
- ❑ The ray model is the basis of *ray optics*.

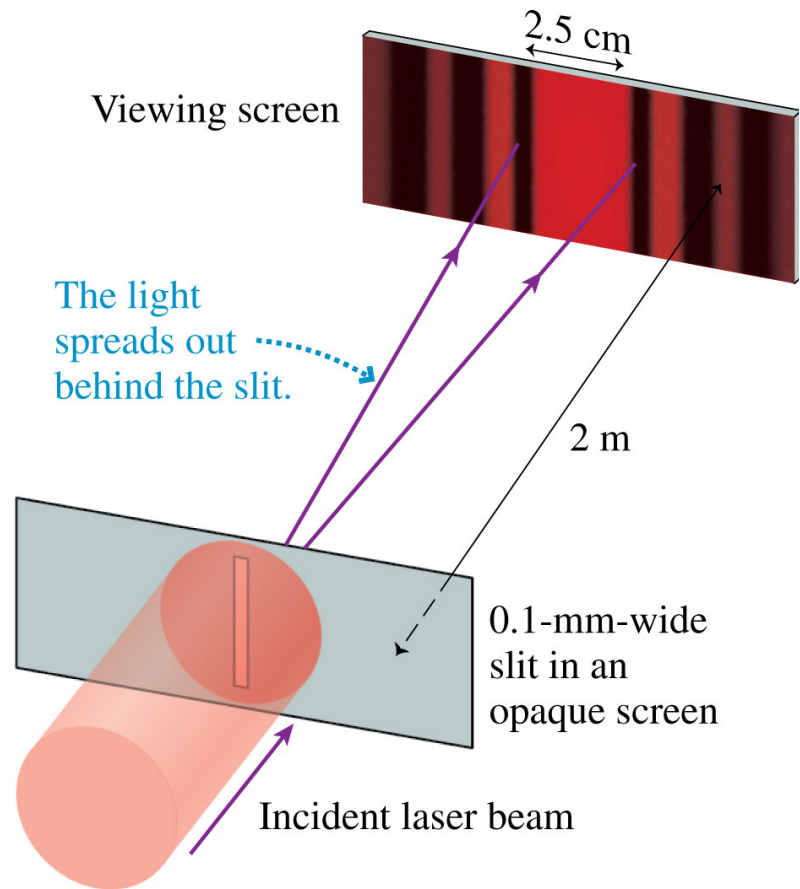
Photon Model:

- ❑ In the quantum world, light behaves like NEITHER a wave NOR a particle.
- ❑ Instead, light consists of *photons* that have both *wave-like* and *particle-like* properties!
- ❑ This is the *quantum theory* of light.

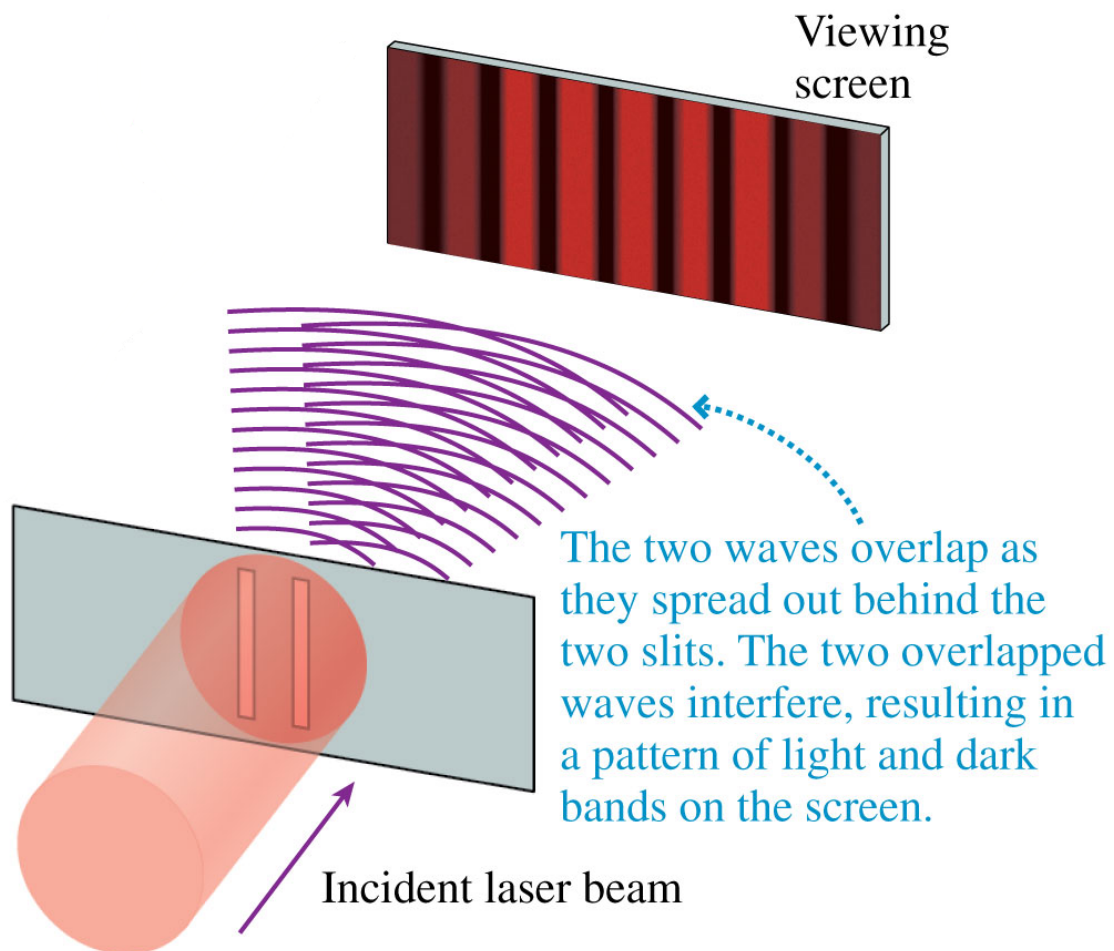
22.2:

The Interference of Light

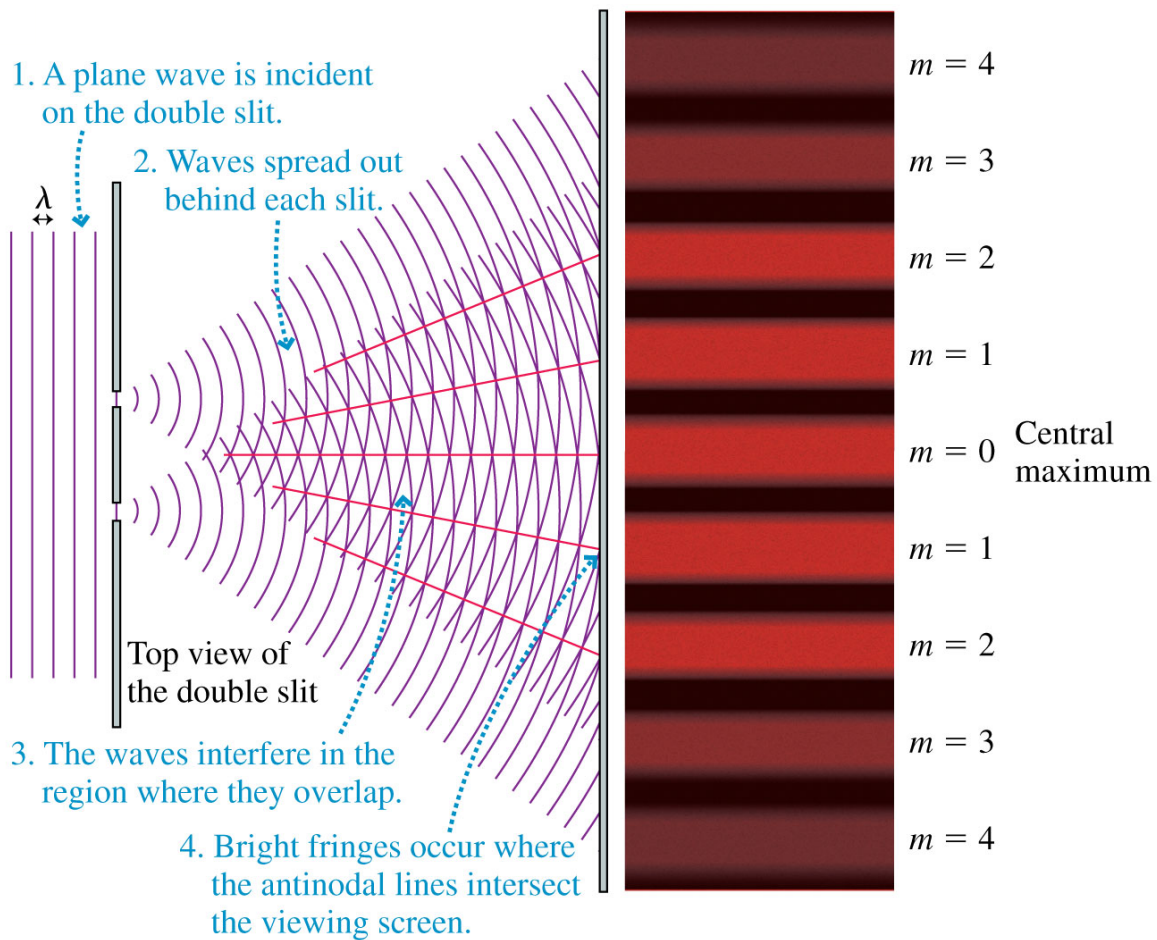
- When light passes through a *very* small opening, it *spreads* out.
- Diffraction of light is observable IF the hole is *sufficiently small*.



Young's Double-Slit Experiment...



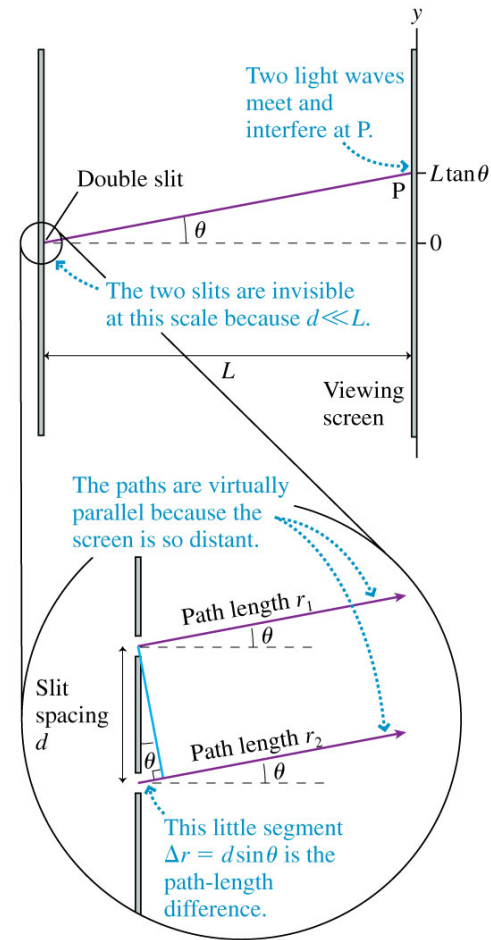
Young's Double-Slit Experiment...



Analyzing Double-Slit Interference...

What are the *angular positions* of the *bright fringes* in the interference pattern?

Where does the m^{th} *bright fringe* occur?



Analyzing Double-Slit Interference...

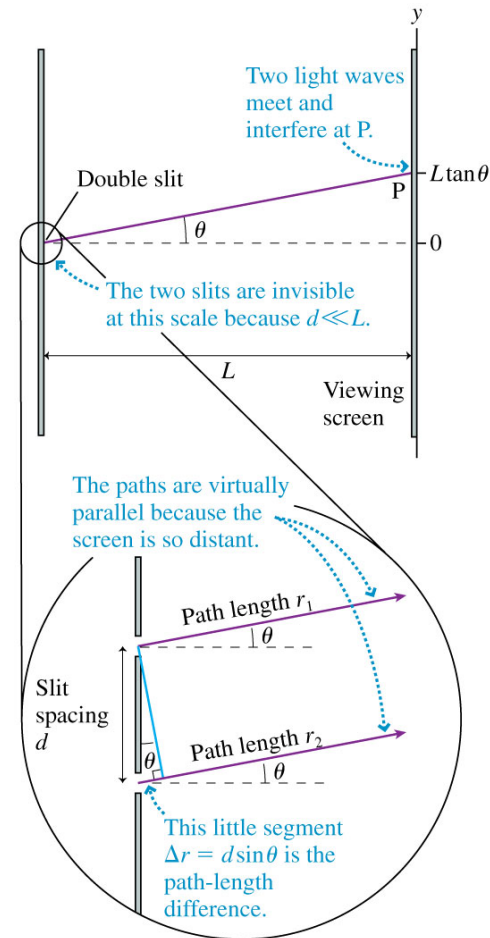
What are the *angular positions* of the *bright fringes* in the interference pattern?

$$\theta_m = m \frac{\lambda}{d}, \quad m = 0, 1, 2, 3, \dots$$

in radians!

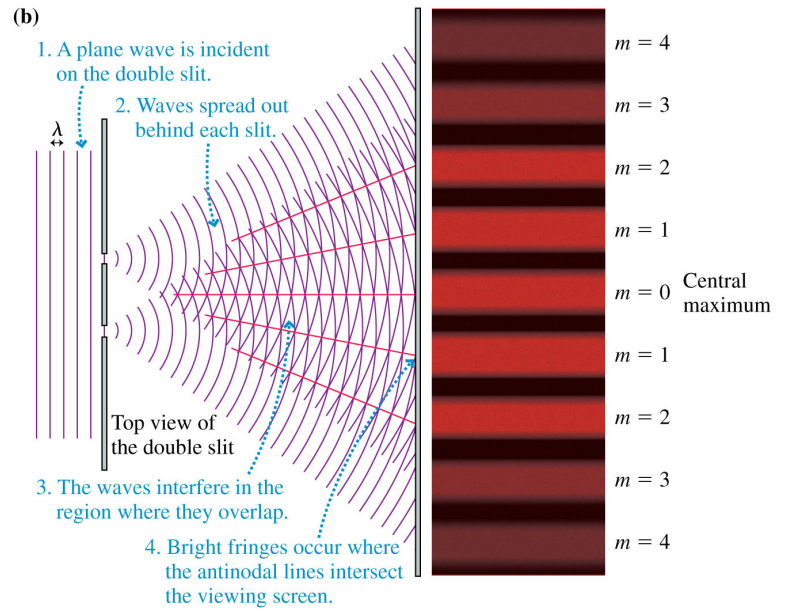
Where does the m^{th} *bright fringe* occur?

$$y_m = \frac{m\lambda L}{d}, \quad m = 0, 1, 2, 3, \dots$$



Analyzing Double-Slit Interference...

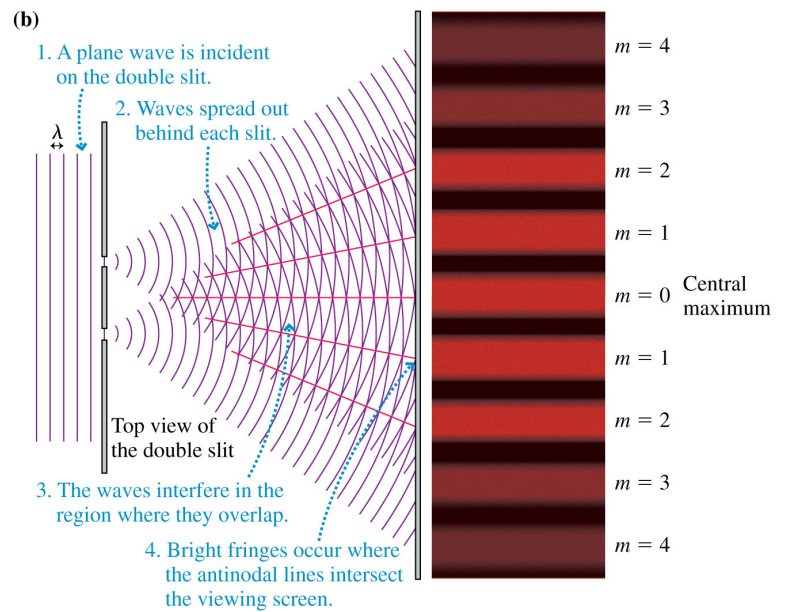
What is the *fringe spacing* between the m fringe and the $m+1$ fringe?



Analyzing Double-Slit Interference...

What is the *fringe spacing* between the m fringe and the $m+1$ fringe?

$$\Delta y = \frac{\lambda L}{d}$$

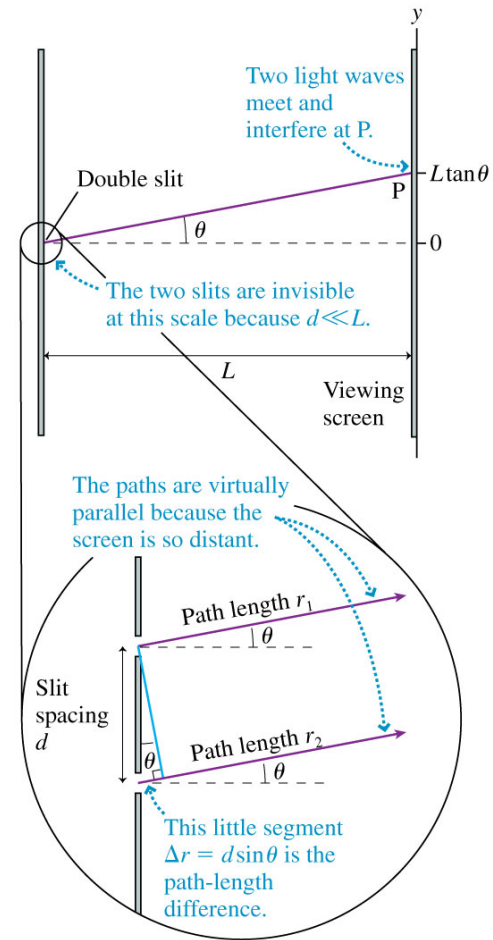


Notice:

The interference pattern is a series of *equally* spaced bright lines.

Analyzing Double-Slit Interference...

Where does the m^{th} dark fringe occur?



Analyzing Double-Slit Interference...

Where does the m^{th} dark fringe occur?

$$y'_m = \left(m + \frac{1}{2}\right) \frac{\lambda L}{d}, \quad m = 0, 1, 2, 3, \dots$$

Notice:

The *dark* fringes are located *exactly halfway* between the *bright* fringes.

